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CONTENTS.

THE GERMINATION AND SELECTION OF TEA SEED.

No. VII of the Mededeelingen van het Proefstation voor Thee consists of an article on the above subject by Dr. Ch. Bernard of which the following is a translation :

I have made certain preliminary experiments with the testing of tea seed, on a small scale only, having in view further experiments regarding the selection of the different types of the tea plant, in connection with the eventual possibility of discovering a variety or race best suited to the circumstances under which tea has to grow in Java ; it will readily be understood that such an enquiry must be preceded by a selection of the seed, so that the first requisite is to discover a method, which will make it possible to distinguish good seed rapidly from inferior. In the following pages the report will be found of observations made, as yet, upon only a relatively small number of seeds. It will be seen (and we would straightway emphasise this) that these observations, based on scientific data and on figures, agree very well with the various methods employed by tea planters, and which rest on a wholly empirical basis. These experiments, on the same lines but on a larger scale, I have repeated with seed of different origin ; the results obtained from them will be published later, meanwhile the results hitherto obtained having been confirmed by this new series of experiments, I believe they will lead to very useful conclusions for practical purposes.

Before describing the experiments we will give a few words to the method which is in common use, which consists of immersing the seeds in water. In practice experience of this method shows that seeds, which have not sunk by the end of 24 hours, are practically certain not to be productive, while the seeds, which have sunk during that time, will, in most cases, germinate. It is seen on opening the floating seeds, that they are either quite empty, or that their content is all dried up or quite mouldy. Every one will have noticed that all the seeds do not sink equally quickly, which implies that they vary very much in specific

gravity. It thus become a question whether the measurement and weight of the seeds may not serve as a standard by which the good seed can be distinguished from the inferior. The seeds on which I worked came from two estates in Java, the names of which do not signify for this purpose, and which we will distinguish by the letters A and B. These seeds were sorted out as follows:

Seeds from estate A were tested by weight.
" " " A " " " measurement.
" " " B " " " weight.
" " " B " " " measurement.

These seeds were sown at Pasir Sarongee, the four groups being kept separate in the nursery beds.

Observations were made as to the rapidity of germination in these seeds, and especially as to the more or less rapid growth of the young plants. At certain intervals the number and appearance of the plants of each group was observed, and we were then in a position to make graphic representations of the figures thus obtained in comparison with the already ascertained measurements and weights. As we have already said, one cannot yet ascribe any practical value to these graphic representations, for they deal with only a few hundreds of seeds, and it is therefore superfluous to publish them here. But the following observations may nevertheless be drawn from them, *viz.*—

1. The very heavy seeds (3-4 gr.*) and the seeds of the largest measurements (19·20 mm.†) were too few in the different groups to be taken into separate account.

2. The tests based on measurements of the seeds gave very little information, with the exception of seeds with a maximum diameter of 11-13 mm., *i.e.*, the very small seeds, which always yielded bad results. It appeared to me impossible to make any distinction between seeds of the different groups with diameters varying from 13 to 19 mm.

3. Tests based on weight appear to me to be more important; in the case of the seeds both from estate A and estate

* gr.=grammes 1 oz.=28·349 grammes.
† mm.=millemetres 1 in.=25·4 mm.

B I found that those weighing between 2 and 3 grammes produced seedlings of the most regular appearance and most vigorous growth on germination. Seeds with a weight of under 0·6 grammes either did not germinate or yielded weak and sickly plants.

4. Finally, I found that on the whole seeds from estate A were generally smaller though heavier than those from estate B, so that they were denser, and it was noticeable that these seeds with a high specific gravity produced seedlings of very much better appearance than did the other seeds. The conclusions I would draw from the above are that seeds too small and too light should not be used, and that the best results are to be obtained from seeds which have good average measurements and are as heavy as possible.

The indications thus obtained from specific gravity led to the following experiments for I was anxious to find some way more convenient in practice than the measuring and weighing of seeds.

Seeds from estate A were immersed in watery solutions of glycerine, containing from 10% to 80% of glycerine, the solutions thus being of very various specific gravities. No account was taken of seeds which floated in water; with the exception of these, 8 different groups of seeds were obtained of constantly increasing specific gravity. The lightest of these seeds were those which would only sink in plain water, while the heaviest were those which would sink only in a 70% glycerine solution (all the seeds floated in an 80% solution). The eight groups of seeds were sown separately; after a few months it was evident that the heaviest seeds had yielded the most vigorous plants with the most regular appearance, whilst there was a fairly constant corresponding diminution in these properties as the seeds became lighter. As I said above the numerical data are not yet positively established, because the experiment was carried out with a small number of seeds; but I believe that the results of the repetition of the experiment, which has already been repeated on a large scale will, confirm the results first obtained.

For a further experiment liquids were used as follows :—

1.	Alcohol	50 per cent.
2.	Water.	
3.	Glycerine	20 „
4.	„	40 „
5	„	50 „

In these liquids seeds from estate C were immersed; those seeds that floated in an alcohol of 50% strength were left out of consideration. The results were as follows :—

In 50 per cent. of alcohol ...	200 seeds sank.
„ water	192 „ „
„ 20 per cent. of glycerine ...	216 „ „
„ 40 „ „ „ ...	88 „ „
„ 50 „ „ „ ...	329 „ „

These seeds were sown in the early part of 1909; when they came up, it was seen that the seedlings of the 4th and 5th groups were without exception finer and more regular plants than those of groups 2 and 3. Seeds of group 1 were very bad; fully 50% did not germinate. It must be observed that the seeds remained only a few minutes in the different liquids, while the previous experiments showed they did not suffer at all from a short immersion either in alcohol or glycerine.

Similar results were obtained on a repetition of these experiments with other seeds so that it is highly probable that the above named liquids form a good practical scale of comparison in the selection of seeds.*

With a view of ascertaining beyond a doubt whether the qualities of the seeds that could be subjected to measurement, such as weight, dimensions, and density, exercised any influence on the rapidity of the germination, the diameter and weight of about 100 seeds were measured.

Now by dividing the weight by the diameter, one gets a simple method of ascertaining sufficiently exactly the relative density of the different seeds. These seeds were now put into damp sand,

* In my last experiments I used, instead of the rather expensive glycerine, solutions of sugar, which gave equally good results.

care being taken that they should all as far as possible be submitted to just the same circumstances; observations were then made of the time at which the shoot of each seedling first appeared above the surface of the sand. In connection with the various ascertained factors (weight, diameter, specific gravity) graphic representations were made, and in these the three curves present a practically regular appearance, all having corresponding irregularities and thus a practically identical course. It follows that neither of the factors of diameter or weight, and consequently also not the density, gives any indication as to the speed with which the seed will germinate,—a result that was indeed to be expected. The rapidity with which tea seed will germinate depends on many, for the most part still unascertained circumstances, so that seeds all out of one parcel cannot be mutually compared with one another as regards the time that occurs between planting and germination. Still, it is possible that such an experiment would yield results if carried out with seeds collected under exactly the same circumstances.

With regard to the immersion of the seeds in water, I would point out that this must be done immediately the box of seeds is opened, if the idea is to check the guaranteed quantity of sinking seeds. For if the box is opened, and the seeds left exposed to the air for even a short time, they get dry, and the percentage of sinking seeds is very quickly lowered. This is not equivalent to saying that the germination capacity of the seeds is diminished to the same extent; this will be demonstrated by the following experiment and by other facts to be communicated later on. One parcel of seeds was put into water directly they were received, 75% sank almost immediately while another 15% sank after remaining 24 hours in the water. I then let these seeds lie for six days in the air, and then put them into water again, when it was found that only 50% sank after 24 hours; but the seeds immediately after this gave 70% of successes.

I think it would be superfluous to remark that the seeds must not remain too long in the water; 24 hours is a maximum stay; and care must be taken, when running water is not available, to renew the water repeatedly. In stagnant water after 24 hours one sees the liquid get turbid; it contains a great quantity of bacteria,

and fermentation takes place, as is evidenced by the formation of gas and the arising of an unpleasant smell. Some of the seeds then begin to deteriorate inside, especially in the case of seeds that are at all old, which show traces of mould on the thinnest parts of the husk.

The disadvantages of too long an immersion are so well known to all planters that I will not dwell longer on the subject, but will merely remark that it is a question whether the disease by which the young plants are attacked, which has been the subject of observation elsewhere,* and to which we shall return again, is not connected with this circumstance.

Instances of disease however may occur in the young plants when the seeds are a little old, and so do not sink immediately on being tested, so that they remain a long while in the water. Doubtless they begin to get mouldy there, and even to rot. Now I have been able to prove that the seeds are always attacked first at the point where the husk is the thinnest, that is at the eye ; now it is exactly at this point that the little rootlet makes its appearance out of the seed, and it is easily understandable that its tender tissues are at once infected thereby. The conclusion to be drawn from these facts is therefore that the seeds which show signs of mould round the eye must be rejected ; perhaps the evil might be remedied by disinfecting the seeds in the way I have elsewhere† suggested in other cases. But, we may conclude it is of the highest importance not to lay out nurseries in damp places or, if it is done, to provide for the necessary drainage for carrying off the superfluous water.

I said above that the fact that seeds do not sink in water, does not always mean that they have lost their germination capacity. As an example of this I will relate the following : I received some very fine seed from an estate in Java, at least three-fourths of which sank in water ; circumstances were such that the seeds had to lie for two months in the laboratory ; at the end of this time the seed was put into water again, and it was found that after 24 hours, not

* Diseases of the Tea Plant (Preliminary observations). Reports of the Tea Experimental Station, Java. II. p. 34, 1908.

† Diseases of the Tea Plant caused by Mites. Reports of the Tea Experimental Station, Java. III. p. 64, 1909.

a single seed had sunk. Only after two days did about 50% sink. Fermentation had taken place in the water, so that a great number of the seeds were spoilt; still it was found that, of the seeds which had sunk only after two days, about 40% germinated normally.

Seeds from another estate were kept about 4 months in the laboratory; this length of time had absolutely destroyed all germinating power; when planted out in damp sand, not a single seed germinated, and not one was able even to burst its hard skin. In testing these seeds it was found that, after two days, there was only a very small number of seeds which sank in water. After 3 or 4 days the non-buoyant seeds were about 50%, but this was in consequence of the rotting of the seeds, which had attacked the outer skin, which therefore admitted the water; in this case therefore the sinking had nothing to do with the germination capacity; all the seeds were found to be spoilt inside.

One frequently hears references to the bad consequences of putting the seeds into the earth with too little care, and the best method of doing this forms the subject of discussion. Some planters are of opinion that it is preferable to put the seeds into the ground with the eye on one side; but botanically it is certain (while experiments made up to the present confirm it) that the most logical way, and consequently the method which gives the best results is to put the seeds into the ground eye downwards; information, also, supplied by practical men, has confirmed our view on this point. Many planters, therefore, use this method and get good results; while others do in fact the same thing indirectly, by first letting the seeds germinate on a bed of damp sand, and the germinated seeds are then immediately put into the ground in the normal position, *i.e.*, with the rootlet downwards. But in this matter also confirmation must be obtained by methodical experiment of the results one gets empirically; the more so as some planters prefer to put the seeds into the ground with the eye on one side or, what is more serious, to plant them haphazard without thought.

In the first place it is important to show that the eye (Fig. I. a.) is a spot where the hard shell of the seed offers less resistance than anywhere else. We have already seen that this is the place where

the seeds begin to get mouldy. It is also here that one can easily stick a pin into the seeds, which cannot be done anywhere else except with much more trouble. Seeing that the eye is thus the weakest place in the shell of the seed, it is easily understandable that it is here the husk first opens when the swelling of the seeds lobes necessitates the bursting of the shell. We have actually seen this taking place in the germination ; of the hundreds of seeds which were put into damp sand there were only a few (about 2%) in which the shell had burst at any other place than the eye ; in all the other seeds this had taken place exactly at this point. (Fig. 2, 3, 8, 15, etc.)

We will now show reasons for saying that, if the seed is to be put in a normal position, it must be set eye downwards in the ground. In the first place we see, if we open a seed, that the rootlet is directed accurately towards the eye (Fig. 1) so that it is at this point, as we have seen already, that the seed begins to split; and it is always the rootlet that developes first in the process of germination ; therefore it is plain that, if the eye is placed downwards, the rootlet finds its way unhindered into the ground and pushes down into it *unbent.* (Fig. 3 to 6). Moreover, in this case, the two seed lobes are placed vertically, the division between them also being vertical (Fig. 4 and 5). Now, when the seed lobes begin to swell, the crack in the wall of the seed increases, so that it splits into two almost equal halves. (Fig. 4, 5, 10, 11, 12). Once the shell has burst, the seed lobes fall apart by their own weight (Fig. 6) thus leaving a free passage for the lengthening of the little stem, which begins to develop at that very moment. Obviously, therefore, by working in this way the young organs are obliged to exert only the minimum of force, which is just what we want to insure.

From this we have seen that the important result obtained by putting the seed eye downwards, *viz.*, that the root runs almost no danger of getting bent which is the case when the eye is put on top (Fig. 14 to 18) ; also, although to a less degree, when it is at the side (Fig. 8 to 12); we suppose everyone knows the disadvantages entailed by a bend in the root. The curvature of the stem, which also occurs in the seedlings, which have germinated in an abnormal

position, is less serious, but it has been shown that this causes knots on the neck of the root, which although not dangerous to the plant, retard its growth.

By way of experiment a few seeds were planted in different ways, *viz.*, some with the eye downwards, others with the eye upwards, and some few finally, with the eye sideways.* Two months after the germination it was plainly to be seen that the plants of the first group had come up much finer and more regular than those of the two other groups. It was established that with plants of the first group (with the exception of 2%) the roots showed no trace of curve, while a great number of the plants of both the other groups had the root more or less bent, and this was especially the case with plants which had sprung from seeds having the eye upwards; there were some cases among them where the root had made several bends before finally turning downwards (Fig. 11, 12, 17, 18.)

A similar experiment was carried out some years ago at Sarongge, in which it appears that similar results were obtained; it was demonstrated at any rate, that plants sprung from seeds, which had been planted with the eye upwards were very backward in growth as compared with other plants, where the eye had been

* We have examined a number of seedlings from seed planted at Borbhetta and the results of our observations agree in most particulars with those of Dr. Bernard. With not more than two or three exceptions per cent. seed planted with the eye upwards developed normally as far as the shoot was concerned, but with a bending round the outside of the seed on the part of the root, the direct downward growth of which was prevented by the presence of the seed immediately below it. This bending, though marked, would probably not be sufficient to produce an unhealthy plant. In a few cases the shoot, before it was able to turn upwards, was caught between the cotyledons of the seed or by the seed coat, especially if this broke irregularly and not in the plane of junction of the cotyledons. Seedlings with such bent shoots are not likely to develop into normal healthy plants.

Seedlings with the eye placed on the side behaved differently according as the plane of the junction of the cotyledons happened to be vertical or horizontal. When the plane was vertical the seedling usually developed satisfactorily with perfectly straight shoot and root. In this case the stalks of the cotyledons elongated so that the shoot was clear of the seed before it grew and no bending took place. About 67% of the seedlings examined were perfectly straight. In about 20% of cases there was a slight bending of the root before it assumed a vertical direction. This could be correlated with a horizontal or oblique

planted downwards. But I ought to point out here that in this case, the nursery beds had not been laid out to demonstrate this point very clearly, so that it is not impossible that other factors exercised an influence on the irregular coming up of the plants of the different groups.

Exactly identical results were obtained on the repetition of the experiment in the laboratory. In this case 3 groups each of 100 seeds were planted in damp sand in the three different positions already described. All the seeds, with very few exceptions (about 1-2%) germinated at the eye; but while the rootlet in the case of those seeds, which had been planted eye downwards, grew straight downwards vertically, the seeds in which the eye was at the side showed a bend at once, while the roots of those of the third group (those in which the eye had been put upwards) were very strongly curved. As the plants developed this curve further increased; and it was very plain that the seedlings with such curved roots were very much retarded in their growth as compared with the others.

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direction of the plane of junction of the cotyledons. When this plane was quite horizontal there was a tendency for the shoot to grow between the cotyledons before growing upwards and in one case the root was entangled between the cotyledons before growing downwards.

When the seeds are planted with the eye downwards the invariably excellent results recorded by Dr. Bernard were not obtained. It is true that a large percentage develop into perfect seedlings. This takes place when the cotyledons open entirely soon after the root has developed and allow the shoot to grow upwards without obstruction from the seed itself. A very common occurrence however is for the root to develop perfectly but the shoot to find a way round the edge of the opening seed and develop a slight curve in doing so. When the cotyledons have opened widely before the shoot develops this curvature does not take place. In a few cases the cotyledons had evidently opened before the development of the shoot, but the seed coat had split irregularly and not in the plane of junction of the cotyledons, and the ascending shoot had been obstructed by it and had turned and twisted in trying to grow upwards with the production of a useless seedling.

To summarise these observations it appears that to get the greatest percentage of straight roots, the seeds should be planted with the eye downwards, though as many seedlings with straight shoots are produced from seeds planted with the eye on the side as from seeds with the eye below. Seeds planted with the eye above have straight shoots but never have quite straight roots.

We propose to make further experiments next autumn to determine the causes of deflection of the root after it has left the seed.

There is no doubt that less difficulty arises when the eye is at the side than when it is at the top; in the former case the organs frequently, though with difficulty, resume their normal positions (Fig. 13); still there is always more or less chance, and the division between the two seed lobes may happen to be horizontal (Fig. 10 and 11) which hinders the development of the little stem. To sum up, one concludes that it is wrong to plant the seed haphazard, or even exclusively with the eye at the side; the best method is to sow the seed with the eye downwards.

The method referred to above of letting the seed germinate first, in order to plant it with the eye downwards, is a very good one when there is any uncertainty of the quality of the seed used; as a matter of fact it is nearly the same thing as sowing it eye downwards, except that it has this disadvantage, *viz.*, that when the tender rootlets are just developed, they may be damaged in carrying the germinated seeds to the gardens or in too roughly transplanting them into the ground. Such disadvantages are avoided by planting the seeds direct into the earth, but in that case only seeds of good quality must be used, and even of those only such as sink in water; if this is done all the seeds with very slight exceptions should succeed. It has been objected to all these careful proceedings in regard to planting, that nature itself takes no such care. This is something to which I would just here draw attention, and indeed it cannot be too much insisted on, that plants under cultivation do not exist under natural conditions. If we want to get plants under cultivation as normal as possible, they must be removed from the laws of chance to which they are subject in their natural conditions. In so far as this applies to our subject, it must be remembered that out of all the seeds which are developed on a tea-plant growing *wild* only a very small number, *i.e.*, those which happen to develop in favourable circumstances will actually grow: while in *cultivation* it must be our special object to make the number of failures as few as possible.

Explanation of the drawings.

Fig. 1. Cross section of a tea seed, enlarged $2\frac{1}{2}$ times. The husk is shown black, except the "eye," which is drawn in lighter. The embryo plant is situated at the basis of the seed lobes.

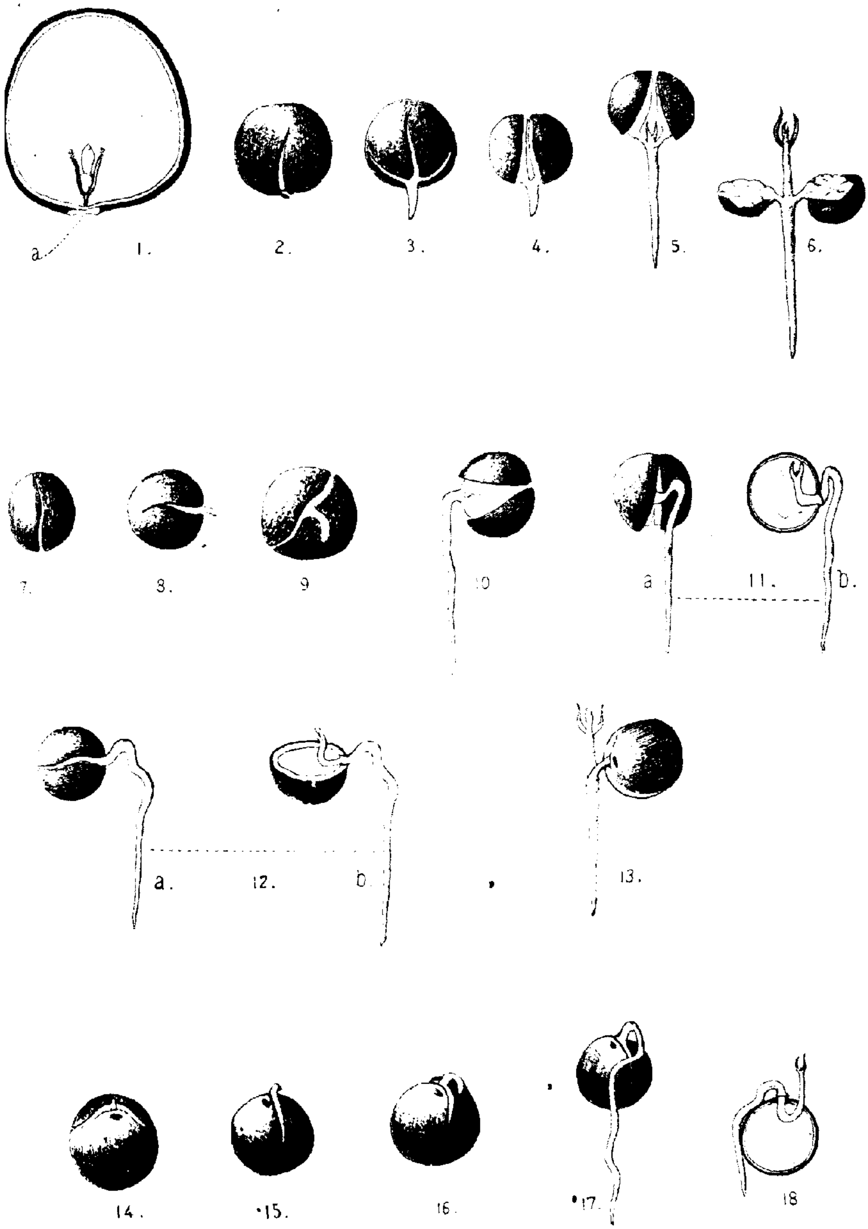
Figs. 2—6. Seeds planted in the ground with the eye downwards; the husk begins to split at the eye, and the rootlet grows down without any curvature whatever, the seed lobes separate and give free passage to the stem.

Figs. 7—13. Seeds planted with the eye at the side. The curve in the young root is easily seen; the seed lobes may also lie horizontally (Fig. 12) which causes a bend in the stem; or (Fig. 13) the little stalks of the lobes may grow out, and this brings the little plant into normal position again. (Drawings a and b in figures 11 and 12 are of the same seedling seen from different positions).

Figs. 14—18. Seeds planted with the eye upwards. The rootlet pushes first upwards, and afterwards makes a strong curve downwards. The stem is also sometimes very markedly distorted.

Figs. 2—18 are actual size.

By the eye of the seeds is meant the round scar marking the place where the seed was attached to the cover of the fruit.


a
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18

THE MANUFACTURE OF CHARCOAL.

The following article is reprinted from The Journal of the Board of Agriculture, Vol. XXI, No. II, February, 1915, because the question of the production of charcoal is one of general interest to planters.

Through the kindness of a Forest Officer we are able to preface the article with a few notes on woods suitable for the preparation of charcoal in Assam and Bengal.*

The best charcoal is made from hard woods, and these are often too valuable to be utilized in this way. In the Surma Valley, however, where the forests have been very heavily cut over by traders, there are two hard woods which they have been unable to extract, and consequently both species are common and increasing, especially in the Manipur forests bordering the Barak.

One is Chelta (*Dillenia indica*), the common Assamese "Otenga", and the other Ping (*Cynometra polyandra*). Both these trees have hard, heavy woods, yield first-class charcoal, are common in easily accessible localities, and have no market value in any other form.

Otenga is common in Assam too. Nahor or Nagessur (*Mesua ferrea*) yields first-class charcoal, too, the wood being hard and heavy. Nahor sleepers and posts are excellent, but so difficult of transport, that there is no prospect of them ever being used much. Practically no Nagessur came out from Manipur before the war, because the more wealthy people, who could afford to extract it, had discovered that it was almost as cheap to use iron posts when building : hence Nagessur should be available.

Sal (*Shorea robusta*) also yields first-rate charcoal, and there is much in the way of large tops and branches, that now goes to

* In the next number of the Quarterly Journal another note on this subject, which reached us too late for incorporation in this issue, will be included.

waste when working out sleepers and scantlings, that could be used for charcoal burning. Unfortunately, most Sal forests are too far away from the Tea districts to make the industry profitable.

In the Surma Valley Chelta, Ping, and Nagessur alone could supply any sized market with really first-class charcoal for many years. In Assam, Otenga, Nahor, and a species of Siris would have to be supplemented by other softer species. The names of these latter are legion, and although the charcoal from them is not so good as from the harder woods, the evergreen forests could supply an unlimited amount of reasonably good charcoal.

In consequence of the war the demand for charcoal both for heating purposes and for munitions of war has already greatly increased and it is probable that this will be the case as long as hostilities continue. Owners of wood lands may find it advantageous to consider whether they could not profitably turn some of their less valuable material into charcoal. There is no great difficulty in manufacturing charcoal in kilns: the initial expenditure is small, and the amount of skilled labour required is not very great, while at the same time wood which might not otherwise be utilised is turned to account. It would be unwise, however, to attempt to make charcoal without some skilled labour, and although it has been found possible in an emergency to employ 20 to 30 unskilled men under a skilled charcoal burner and a good foreman there are some operations which only a skilled and experienced man can efficiently perform.

Selection and Preparation of Wood.—Since it is important that carbonisation should proceed evenly, different woods varying much in density should not be burned in the same kiln. Thoroughly air-dried wood is most suitable, but green wood can be used if a small amount of dry wood is put in the centre of the kiln. Decayed wood should on no account be used. Large pieces of wood, (*i. e.*, of about 8 in. or more in diameter) should be split and trimmed straight. Crooked and bent branch-wood can be used only in short pieces. Usually cord-wood in lengths of 2—3 ft. is employed.

FIG. 1.—Making the Heap.

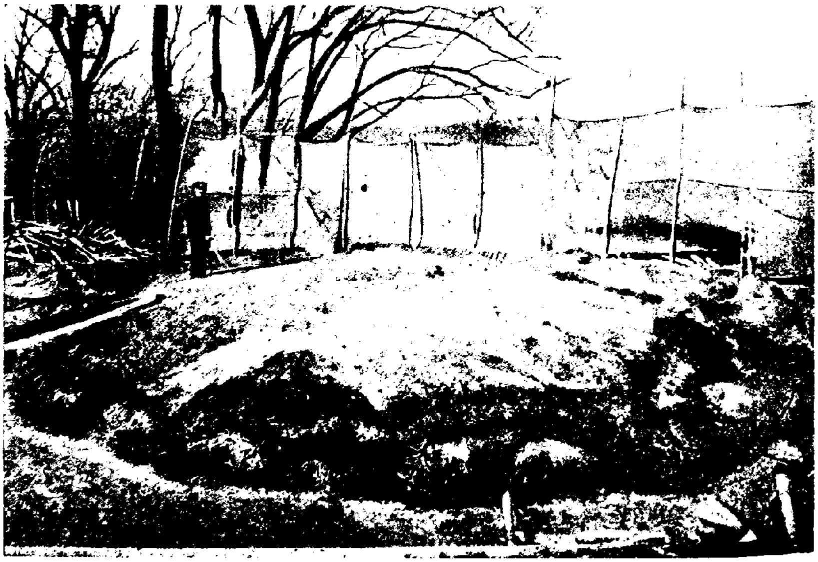

FIG. 2.—Opening the Kiln.

Site for the Kiln.—Level, well-drained ground, sheltered from the wind* and in close proximity to the wood and to a water supply, represents the best site for a kiln. A sandy loam is the best soil upon which to make the hearth. The soil of the hearth should be of a uniform nature and for this reason the ground must be freed from vegetation, etc., and prepared as carefully as a garden bed. The centre of the hearth is raised 8 to 12 in. above the circumference, and slopes evenly down to it, in order that the liquids produced in the process may drain away and that the draught may be increased.

An old hearth is always preferable to a new one: in any case the admixture of charcoal dust from old kilns with the soil of the hearth produces conditions most favourable to efficient carbonisation.

Before the kiln is piled, a heap of brushwood or other easily combustible firewood should be burned upon the hearth in order to dry it.

The method of constructing and burning charcoal kilns differs in detail from place to place. The method described below is the one followed in the Forest of Dean, but in general it may be taken as typical of the practice of English charcoal-burners. The illustrations represent operations in the Sussex Weald, but they also are typical of the country.†

Construction of the Kiln.—It is found that convenient sizes for kilns are from 6 to 8 ft. in height and 13 to 20 ft. in diameter a usual size is 7 ft. high and 18 ft. in diameter, giving a capacity of about 8½ cords.‡

The first step in construction is to build a central flue by laying two billets (about 1 ft. or 1 ft. 6 in. long) parallel on the hearth, and piling others across them, continuing in this fashion to a height of several feet: it is not necessary to build this flue to the total height of the kiln, the walls of the top part of the flue

* If the ground is not naturally sheltered wind-screens are used, see Fig. 2.

† It will, however, be noted that in Fig. 1 a central pole has been used upon which to build up the chimney.

‡ A cord=128 (piled) c. ft. or about 64 c. ft. solid of cordwood.

being formed in the process of packing the kiln. Around the flue other billets are closely stacked, leaning against it in a nearly vertical position, the thick ends being usually downwards. Dry, slender billets, are placed next to the flue, the thicker ones being placed about halfway between the centre and the circumference. When some progress has been made with the first tier of billets a second tier is commenced, and later a third and sometimes a fourth. Finally the kiln is made as symmetrical as possible by filling with thin sticks any spaces left by the packing : the top of the kiln is by this process made almost horizontal.

Covering the Kiln.—In order to exclude all air from the kiln other than that absolutely necessary to maintain carbonisation, it is covered with an inner and an outer covering. The inner covering consists of turf, the sods being placed grass downwards. This covering is built upwards from the ground, and varies from 2 in. to 6 in. in thickness. Where suitable turf is not available a covering of dead leaves or grass takes its place. An outer covering of damp earth or of a mixture of damp earth and charcoal dust, about 1 in. thick, is next put on, commencing from the base and working upwards : this is lightly patted down with the back of a spade to keep it in place. The top of the flue is left open.

Firing the Kiln.—Red-hot charcoal is thrown down the flue and the fire so made is kept well alight : when this is assured the flue is filled with small billets of wood. An iron plate is placed over the top of the flue and removed every few hours in order to admit more billets, which are rammed tight with a wooden pole. When the flue is filled with a mass of burning wood the plate is removed and the flue covered in with the same substances as the sides of the klin.

Regulation of the Burning.—The proper regulation of the burning is a very difficult operation, for which it is absolutely necessary to have the assistance of an expert charcoal burner. Constant attention is required day and night until carbonisation is complete : the process may continue from 4 to 6 days according to the size and quality of the wood. The burner is guided in his work by the colour and position of the smoke. When the kiln is first

kindled steam is given off, which changes in time to a white, thick smoke and then to a clear, blue smoke. The method of regulation is to make vent holes to increase the draught and expedite burning, and to close vent holes and thicken or water the covering to retard burning. Vent holes are not made until the second day of burning: they are then made on the sheltered side of the kiln at about two-thirds its height. As the burning proceeds these holes are covered and others made lower down, each series of holes being covered in turn until the base is reached and carbonisation completed.

As the temperature rises and the moisture in the wood is converted into steam there is some danger of explosion. Great care is required to keep the cover in proper condition, so that it is sufficiently porous to let the steam out and not so porous as to let in too much air.

If through uneven packing or other causes hollows appear in the kiln, these must be filled: the cover is removed, the wood or charcoal inside pressed down and the hollow filled with half-charred wood or fresh wood and the covering replaced as speedily as possible.

Opening the Kiln.—As soon as it is perceived that carbonisation is completed down to the base of the kiln, the covering is made air-tight. The kiln has now considerably shrunk and is only about 3 ft. high. The outer covering is raked off with a long-pronged rake,* leaving only the charred turf. The surface is smoothed down with a "rable" (a large wooden hoe) all loose dust being scraped off. Fresh damp earth is thrown on to form a layer of about half-an-inch thick, and finally the kiln is covered with a layer of fine dry dust to fill up all small holes and to make it air tight. If large wood has been used the kiln is cooled down by sprinkling water on it after scraping off the first layer, but this is not necessary with coppice wood.

When the kiln is sufficiently cooled down the covering is raked off about one-sixth of the kiln on the sheltered side and the

* See Fig. 2.

charcoal is drawn out with a long-pronged rake as rapidly as possible. The covering is next taken off the adjoining portions of the kiln and is thrown over the first opening to prevent flaming and to reduce the amount opened at any one time. This process is continued round the kiln till all the charcoal is removed. A kiln is ready for opening on about the fourth day if small wood has been used and on the sixth day in the case of large wood.

As soon as the charcoal is removed from the kiln it is spread over the ground and sprinkled with water. All half-charred pieces are picked out by hand and reserved for filling the chimney of the next kiln. The rest is riddled through a wide-meshed screen and is packed into sacks according to size. The earth and charcoal dust remaining in the centre is riddled and is used for covering the next kiln burnt on the earth.

Yield of Charcoal.—The yield of charcoal depends upon many factors—the kind of wood used, the situation of the kiln, the state of the weather, the methods adopted by the charcoal burner and the degree of his expertness. In similar circumstances coniferous wood will yield more charcoal than wood from broad-leaved species and, of the latter, soft-woods will yield more than hard-woods.

As a result of recent operations in the Forest of Dean it was found that $61\frac{3}{8}$ cords of cord-wood and $47\frac{3}{8}$ cords of pit-wood (all of oak) together yielded in 13 burnings 31 tons 19 cwt. of charcoal, *i. e.*, a little under 6 cwt. to the cord.

Since a cord of oak cord-wood weighs roughly $1\frac{1}{4}$ tons and a cord of oak pit-wood a little more than this, the weight of charcoal produced was approximately 20 per cent. of the weight of wood used.

Cost and Financial Return.—In the Forest of Dean the burning is usally given on contract at from 18*s.* to 25*s.* per ton.* This sum does not include any payment for the cutting or preparation of the wood, which is provided ready cut. Such preparation

* When the burner is paid by the ton he may, if unscrupulous, water the charcoal to increase its weight, and it is, therefore, found convenient in some places to pay by the bushel.

is sold at 5*s.* per cord, so that to the sum paid for labour about 15*s.* per ton of charcoal may be added for the value of the wood.

Besides labour and wood the only other considerable items of expense are sacks for packing and cartage. The sacks used in the Forest of Dean cost about $3\frac{3}{4}$*d.* each and about 40 are required to pack a ton: they are returnable and can be used several times.

In normal circumstances charcoal in large consignments sell at from £2 to £2 10*s.* per ton on rail, while for small quantities (say two or three tons) such as are used for drying hops in South of England, as much as £4 per ton may be obtained. At the present time, however, prices are higher, and large quantities are being sold at from £3 10*s.* to £4 per ton on rail.

PROHIBITION ON THE EXPORT OF SULPHUR FROM THE UNITED KINGDOM.

In Circular No. 6 of the 23rd January 1916, members of the Indian Tea Association were informed of the probable prohibition of the export of sulphur from the United Kingdom. As sulphur is very largely used on tea gardens for the control of red spider, etc., this prohibition may effect the tea industry to a considerable extent. It is possible, however, that supplies may be obtainable from Japan, Sicily, or America, and enquiries are being made by the department with a view to procuring samples of the different brands obtainable, in order to ascertain their merits or demerits from the tea planters' point of view. The results of these observations will be published in this Journal as soon as possible. In the meantime it may be not inadvisable to point out some of the ways in which sulphur can be economised, and alternative substances which can be used in cases where sulphur is usually applied.

On tea gardens sulphur is usually dusted on to the bushes with bags. It has often been pointed out that it is best to apply sulphur only in the early morning, when the dew is on the bushes, and the sulphur will adhere to the foliage. This practice, though it is generally recognised to be a good one, is not by any means adhered to, with the result that a good deal of the sulphur applied is blown off by the first puff of wind, and a good deal of wastage occurs. Similarly, it is very wasteful to attempt to apply sulphur in a wind. This, of course, is obvious, yet seldom, if ever, does one find that sulphuring is abandoned on a windy day.

Further economy can be effected by the use of lime-sulphur solution instead of sulphur. This solution, though more efficient than sulphur as an insecticide, is not in such general use as it deserves to be on tea estates, chiefly owing to the fact that its preparation entails a certain amount of care and supervision, while its application necessitates the use of sprayers, but it might also be

applied, if desired, by means of swabs on short bamboo handles The following description of its mode of preparation is reprinted from "Notes on the Spraying of Tea," Indian Tea Association Pamphlet No. 1—1915.

Lime-Sulphur solution is best prepared, for insecticidal purposes, according to the following formula :—

Quicklime	...	...	...	20 lbs.
Sulphur	...	...	...	22½ ,,
Water	...	...	...	50 gallons.

"The lime should be put into a drum holding 50 gallons and slaked by adding water gradually. When it is fully slaked, add about 30 gallons of water, and bring to the boil. When it is boiling add the sulphur gradually, stirring vigorously during the whole time, and when all the sulphur has been added pour in boiling water to the 50 gallons mark. Boil for an hour longer, keeping the volume at 50 gallons by adding *boiling* water. This gives the stock-solution, which, when cool, may be diluted with 10 or 12 volumes of water and used immediately. It is a useful spray fluid for Red Spider.

Great care must be used in its preparation, and if it be desired to keep the stock solution, it must be stored in full, air-tight vessels, or, if the vessel is not full, with a layer of oil on the surface.

The best lime-sulphur solutions are those prepared on the garden as required, if they have been made properly, but experience shows that these home-made solutions are of very variable efficiency, and stock solutions may be bought ready made, which only need to be diluted with the requisite amount of water to be ready for use. Such stock-solutions will, it is hoped, be placed on the Calcutta market shortly. The same care must be observed in storing them as in the case of the home-made stock solution.

Lime-sulphur solution should not be stored in copper vessels or sprayed into the bushes from copper spraying machines. Great care must be taken to see that all spraying machines are thoroughly cleaned out after use."

In Part III of the 1913 volume of this Journal a formula was given for lime-sulphur in which 80 lbs. of sulphur were used to 36 lbs. of lime. It was subsequently found that this mixture contained an excess of sulphur. and the better formula quoted above was therefore given in "Notes on the Spraying of Tea." In spite of this, many people still use the older formula, which, in addition to being less effective, necessitates the use of much more sulphur. Will those people please note, that they can economise in sulphur and at the same time lose nothing in efficiency, by using the newer formula ?

Should sulphur not be procurable, there are several spray solutions which can be used in a similar way to lime-sulphur. For insect pests Potassium Sulphide or Crude Oil Emulsion may be used. Details of both these spray fluids appeared in "Notes on the Spraying of Tea," and are reprinted below.

Potassium Sulphide.—This substance is useful both as an insecticide and as a fungicide. It makes a valuable spray fluid for use against Red Spider and other mites. It is at present difficult to obtain in India, but Messrs. Shaw, Wallace & Co. of Calcutta are, it is believed, about to place the commercial form, which is known as liver of sulphur, on the Calcutta market. This commercial form is a mixture of several chemical compounds, and is very variable in composition. Its efficiency depends on the proportion of sulphur which it contains in the form of sulphide. Good samples should contain between 25 and 30% of "sulphide" sulphur. Potassium sulphide should be used against Red Spider and other mites, at a strength of 3 lbs. to 100 gallons of water, *i. e.*, roughly 2 ozs. to a 4-gallon spraying machine.

When using potassium sulphide the following points should be carefully noted :—

1. This substance must always be kept in air-tight tins or jars. It should not be kept in copper vessels, nor should the solution be sprayed on to the bushes from copper machines. Spraying machines used for potassium sulphide should be made either of galvanised iron, brass alloy, or of steel lined with bitumen mastic.

2. The spray mixture should always be made up as required for use.

3. Potassium sulphide has a tendency to scorch the leaves, and should, preferably, be applied only on a dull day, or towards evening.

Crude Oil Emulsion.—The emulsions of the heavier unrefined petroleum oils have somewhat stronger and more lasting insecticidal properties than those of the refined kerosines, and they may be used in practically all cases where kerosine emulsions are used. They have, however, a greater tendency to burn the bushes, and weaker emulsions are, therefore, recommended. These emulsions consist mainly of mixtures of petroleum oil and soft soap in varying percentages, with the addition of sodium carbonate in some cases. They are difficult to prepare, but there is upon the market a preparation, suggested by Lefroy, sometime Imperial Entomologist to the Government of India, sold under the name of "Crude Oil Emulsion," and obtainable from Messrs. Bathgate & Co., Calcutta. This preparation contains 80% of crude oil and 20% of whale oil soap. It may be used at a strength of 1 gallon to 50 gallons of water. The spray fluid must be thoroughly mixed with the water to form a milky solution. This is best effected by thoroughly mixing the crude oil emulsion with a little water and adding the rest of the water to this.

The following mixture has been used successfully against Red Spider in Behar :—

Crude oil emulsion	...	... ½ pint.
Flowers of sulphur	...	... 2 ozs.
Water ...	...	... 4 gallons.

Crude oil emulsion is sold at Rs. 7-8 per 5 gallon drum. Sometimes when the crude oil emulsion is received, the oil is found to have separated out. This means that the emulsion has been badly prepared, and it should be returned, and not applied to the bushes, as the oil will burn the foliage.

For fungus blights Bordeaux Mixture may be used in cases where Lime-Sulphur has been used in the past. This spray fluid

was discovered about thirty years ago by a chance observation made on vineyards near Bordeaux. Lime coloured with a little copper sulphate was used to spray vines growing near roads in order to prevent passers-by from stealing the grapes. It was observed that those vines which were treated in this way were healthier and more productive than the remainder. Millardet and other French scientists made enquiries into the cause of this phenomenon and proved that the benefit was neither due to the lime nor to the copper sulphate but to the substances formed by the combination of the two. Although the mixture of lime and copper sulphate has been recognised as the best fungicide for general use since then, its action was not explained for many years.

The Duke of Bedford and Spencer Pickering have recently made a study of the reaction of copper sulphate with lime, and they published the results of their investigations in the 8th and 11th parts of the Woburn Experimental Fruit Farm. They discovered that the efficiency of the mixture depends on the formation of a definite chemical compound and that any excess either of lime or of copper sulphate interferes with the fungicidal action of the mixture. They ascertained that if certain definite proportions of the copper sulphate and lime are employed the fungicidal properties of the mixture are increased considerably. These investigators arguing from theoretical considerations assumed that the strength of the mixture made according to their formula would be 2½ times that of ordinary Bordeaux mixture. They recommended the following formula :—

Dissolve 6 lbs. 6½ oz. of crystallised copper sulphate, by suspending it in a piece of sacking, in two or three gallons of water in a wooden or earthen vessel. Take about three pounds of good quicklime and slake it in a little water, then put it into a tub with 120 gallons of soft water. Stir the lime and water, then leave it to settle until the liquid is quite clear. Run off 86 gallons of the clear lime water and mix it with the copper sulphate. Make up to 100 gallons with soft water.

Later research showed that other chemical actions took place which still further increase the efficiency making it at least twelve

times that of ordinary Bordeaux mixture. The following formula was therefore recommended :—

Copper sulphate...	...	... $1\frac{1}{3}$ lbs.
Lime water ...	...	... $17\frac{3}{4}$ gallons.
Water to make up to	...	... 100 ,,

Dissolve the copper sulphate separately in about one gallon of water. Put about one pound of quicklime previously slaked into a tub with about 25 gallons of water ; stir this up and then leave it to settle. As soon as the liquid is quite clear pour off $17\frac{3}{4}$ gallons into the solution of copper sulphate. Add the extra water required to make the whole up to 100 gallons. As the lime-water may vary a little in strength it is necessary to test the mixture to make sure that there is sufficient lime to combine with all the copper. Therefore, before adding the extra water, ladle out a little of the mixture and add one or two drops of it to a weak solution of potassium ferrocyanide in a white saucer. If there is any brown colouration it shows that there is an excess of copper. A little more lime water must then be added and the test repeated. The old method of testing with a clean knife blade, seeing whether it becomes stained with copper on being placed in the solution, is unreliable.

The preparation of Bedford and Pickering's mixture demands more care than is usually exercised in the preparation of ordinary Bordeaux mixture, but the advantages possessed by the spray fluid are so marked that it is well worth while to go to the extra trouble in its preparation. The cost of materials is about one-twelfth of the amount required for the ordinary mixture. The mixture made according to the old formula does not exert any fungicidal action until some considerable time after application while that made according to the Woburn formulae comes into action at once.

An important point to remember in the preparation of Bordeaux mixture is that the precipitate should be as finely divided as possible. Experiments were carried out by the same investigators to determine the method of mixing the chemicals which would result in the formation of a mixture composed of finest particles. It was found that the desired result was obtained by

mixing the copper sulphate in a strong solution with lime in a very weak solution. If the best results are desired the instructions given for mixing of the chemicals should be strictly adhered to.

The investigators who discovered the new formula for the mixture realised that in some cases the careful supervision essential to its successful preparation was unobtainable, and they prepared a similar product which may be stored in a condensed form. This has been placed on the market as Woburn Bordeaux Paste.*

The Agents in India are Messrs. Shaw, Wallace & Co., Calcutta.

The use of this paste is recommended on gardens where it is impossible to obtain supervision necessary for the accurate preparation of the Woburn Bordeaux mixture.

The paste has a bluish green colour, but it does not leave so bright a deposit on the leaves of the bushes as does Bordeaux mixture prepared according to the old formula. Its efficiency however is greater.

Bordeaux mixture is one of the best fungicides at present discovered. Besides killing the fungus blights it acts as a general tonic. It also to some extent protects plants from the attacks of insects.

Messrs. Shaw, Wallace & Co. have recently placed a ready-made Bordeaux mixture on the market, which only needs to be mixed with water for use. This mixture is known as "Bordorite," and full particulars of the substance can be obtained from Messrs. Shaw, Wallace & Co.

* Some difficulty has been experienced in rendering this substance resistant to the action of the Indian climate, under the effect of which it tends to decompose. Intending purchasers are, therefore, advised to ascertain from the sellers whether fresh stock is obtainable before ordering their supplies.

THE GREEN MANURE PLOTS AT TOCKLAI

BY

A. C. TUNSTALL, B. SC.

For some considerable time experimental plots of many leguminous plants have been maintained at Tocklai.

The observations made on these plots have been very useful. A few have been published in this journal. But the observations so far published have only been about crops which have proved themselves successful. Many other observations have been made sometimes of failures and frequently of doubtful successes which will in all probability be useful to planters who are giving the question of green manure plants serious thought. In this article we give a description of a number of the more interesting plants which have grown at Tocklai and our opinions on them based on our present knowledge. As it may be necessary to change some of these opinions later they should not be regarded as final.

LEGUMINOUS PLANTS.

THE GENUS DESMODIUM.

Imported species

The first *Desmodium* to be planted on the station was *Desmodium-tortuosum*, this was grown from a few seeds obtained from Queensland, Australia. In spite of every care the plants were poor and stunted. The plant was voted a failure, but, in September 1913 as an experiment, a few cuttings of woody shoots about six inches long were planted out. These grew with wonderful rapidity and the resulting plants yielded seed, which was carefully collected. This seed was planted out in larger plots the next season and a very good crop was obtained on unmanured soil. This year many more plots were planted out from both cuttings and seed. These have been very disappointing but as various other plants of known utility failed last year on these plots it

would not be right to condemn the crop on account of a single failure.

About the same time another imported *Desmodium*, *D. uncinatum*, was planted. This was obtained from an explorer in Texas through the U. S. Government. One plant of this species still survives but cannot be said to be flourishing.

Indigenous species

In the cold weather of 1912 a careful survey was made of the leguminous plants growing in the jungle neighbouring the experimental station. Seed and plants of the following species of *Desmodium* were collected—*polycarpum*, *concinnum*, *retroflexum*, *gyrans*, *parviflorum*, *triflorum*, and a year later *laxiflorum*. From the low lying sandy land near Kokilamookh *gangeticum* was obtained and from the Nambur forest near Manipur Road *pulchellum* and *latifolium*. *Quinquetum* from Nowgong has been added recently. Seed of many of these species have been obtained from other sources since. The Nagas brought down small quantities of *Desmodium concinnum* seed from the hills where it seems to be common. All except *gangeticum* are common in all the plains districts. In Darjeeling *polycarpum* and *concinnum* appear to be commonest.

Desmodium polycarpum.—This is the commonest species of this genus in the tea districts. It is a small plant with clover-like leaves which in October produces purple flowers in clusters. The seed pods break up into divisions, each of which contains a seed.

In the early rains cuttings from the jungle were planted out. The cuttings were of young woody stems. One plot was planted with the ends inclined to the sun, the other away from the sun. The cuttings grew but growth was slow. No difference could be observed between the two plots. Another plot was sown with seed. The seed germinated well but heavy rain killed many of the young plants and buried others. The plants grew well and gave a satisfactory plot. The cuttings gave the quickest results but the seed plot was not far behind. In September 1914 it was obvious that the seed plot required thinning out and cuttings were made from the plants which had been discarded. These cuttings grew much more satisfactorily

than those which were planted earlier in the season. Subsequent experience has shown that September is the best time to plant cuttings of *Desmodium spp.* The plots planted in 1914 were left undisturbed. In December 1916 they showed signs of dying out. If the plants had been pruned regularly they would probably have continued to grow. This species of *Desmodium* has been planted on contour bunds in the tea and seems to be doing its work of protecting the bunds quite well. It is not recommended as a green manure intended to yield large crops in a minimum time ; but its primary function is to prevent wash. Its function as a nitrogen gatherer is secondary in this case.

Desmodium concinnum is a plant very similar in appearance to *Desmodium polycarpum* but of more erect habit. It is more common in the hills than in the plains. It has been grown at Tocklai for two seasons but is not so satisfactory as the latter species.

Desmodium retroflexum.—This plant seems to be more satisfactory than *Desmodium polycarpum* as its stems cling more closely to the ground. Its leaves are roundish and are covered with silver hairs on their under sides. As the cold weather approaches they turn an autumnal brown. The plant is commonly found in thatch land. It grows very well from cuttings. It has also been grown on bunds in tea and has succeeded admirably.

Desmodium pulchellum is distinguished in the autumn by its drooping clusters of small insignificant flowers which are formed between round green bracts. These bracts turn a pretty brown when the seed is ripening. It is found in forest jungle and in its natural habitat is a small shrub which grows about 3 feet high. Under cultivation it improves and may yet be found a useful green crop. Only a few plants have so far been experimented with.

Desmodium latifolium.—This plant is a shrub growing commonly in grass lands. It is very common in the North Cachar hills. It makes a vigorous growth on poor soils and promises to be useful. Only a few plants have been grown as yet but there is now plenty of seed for the sowing of large plots next year. It does not grow well from cuttings.

Desmodium quinquetum differs from the other Desmodiums described above. It has peculiar long narrow leaves with winged stalks. It has been tried and found useful as a green crop on terraces in Darjeeling; but it does not appear to be so promising as some of the other species.

Desmodium gangeticum is a bushy plant sometimes found on grass land near the Brahmaputra. It is said to be common in Bengal. So far only one plant has been grown but seed is being collected for next year's plots.

Desmodium laxiflorum is too straggling to be of any use in tea.

Desmodium gyrans, parviflorum, triflorum and *parvifolium* are too small and delicate, and experiments with them have been abandoned.

THE GENUS CROTALARIA.

Various species of this genus of leguminous plants have been experimented with for several years. *Crotalaria juncea* is already well known as a green manure and it is unnecessary to deal with it in this article.

Crotalaria striata is one of the commonest leguminous plants on the sandy wastes near the Brahmaputra. It is a bush with trifoliate leaves and spikes of yellow flowers. The seeds rattle in the seed-pods and the plant is sometimes called jhunjhunia by the Assamese on this account. It grows vigorously on the poorest soil and yields a large quantity of green material in 8 or 10 weeks. It will grow without manure where other crops would fail. The roots are covered with nodules and analyses of the plant show that it is rich in nitrogen.

Crotalaria sericea is a bushy plant common round about villages in Assam. It has a more succulent leaf than *Crotalaria striata* but the plots at Tocklai have been so badly attacked by insects that it is not at present recommended.

Various other species of this genus have been grown in plots this year but without any favourable results.

The genus Phaseolus.

Plots of the following species have been grown for comparison : *Phaseolus mungo, radiatus, and calcaratus.* The *Phaseolus mungo* was better than the others but there was not much difference.

Cowpeas.

The plots of Cowpeas were altogether superior to the *Phaseolus* crop. Various imported and improved varieties were tried. As a general rule the larger the seed the better the crop and where seeds were of the same size the fawn and brown varieties were better than the white ones. This crop is very much the most satisfactory ground crop where there is enough labour to hoe it in.

The genus Indigofera.

Indigofera arrecta.—The Natal-Java indigo has been grown with a marked success. This species is likely to be useful as a green manure planted like *Tephrosia candida* in the early rains, cut two-three times during the growing season, and finally cut right down in the cold weather. It becomes very straggling in its second year, and as a crop intended to occupy the soil for more than one year, it cannot be recommended on that account. As this plant yields a valuable dye and the process of extraction of the dye does not reduce but increases the manurial value of the plant, it may be found profitable, where labour and other conditions permit, to grow it among the tea, and after extracting the dye manure the tea with the refuse.

Indigofera dosua.—This plant is common in the valleys of Sikkim. It has been used with success by Mr. Wernicke of Darjeeling in place of *Tephrosia candida.* The plots which have grown at Tocklai have demonstrated that it grows quite satisfactorily in the plains. Its growth is slower than *Tephrosia candida* at first, but as soon as it gets a start it grows more rapidly. It stands cutting well. It is certainly a better crop than *Tephrosia candida* for the higher elevations and bids fair to be so in the plains. It survives for many years in the hills.

Indigofera galegoides is a plant of vigorous growth, not quite so rapid as that of *Indigofera arrecta*. Only one plant has been obtained so far, but a good supply of seed has been collected for this year's sowing.

THE GENUS CASSIA.

Cassia occidentalis is one of the commonest leguminous plant in the tea districts. It is the yellow flowered plant which grows by the road sides everywhere. Plots of this plant grew very well but as it does not seem to be able to fix nitrogen, its use in tea is not recommended, as many other plants which fix nitrogen grow quite as well.

Cassia hirsuta which grows in profusion in the sandy river beds in the Dooars and Terai was also tried, but did not give such a weight of green manure as *Tephrosia candida*.

Cassia tora was also tried but it did not give good results.

THE GENUS TEPHROSIA.

Tephrosia candida was grown for comparison with other plots. It needs no description.

Tephrosia purpurea was also grown. This plant resembles *Tephrosia candida* but it has purple flowers and only attains a height of 2-3 feet. It affords good protection to bunds, etc., and may be useful as a cover crop between young tea.

THE GENUS URARIA.

Various species of this genus have been collected from jungle. The plants grow well but their habit is too straggling for them to be of much use in tea. Under cultivation they are improving and experiments with *Uraria hamosa*, *hirta* and *crinita* are being continued.

THE GENUS SESBANIA.

Sesbania egyptiaca (Jyanth) was grown for comparison with *Sesbania aculeata* (Dhaincha). The former had short spines on its young stems while the stems of the latter are smooth. The Jyanth plots were not so good as those of the Dhaincha.

VARIOUS GENERA.

Clitoria cajanifolia was grown from seed imported from Java by the Chief Scientific Officer. The original plot is still flourishing and it would seem that this plant is likely to be exceptionally useful for the preservation of bunds, etc., as well as for ordinary green manuring purposes. It would be of particular value for sowing in young seed gardens and between young tea. It does not grow very high so that it is not likely to make the young plants grow up too tall. It eradicates sun grass and other jungle. It has been grown successfully from cuttings but does better from seed.

Leucaena glauca a plant introduced by the Chief Scientific Officer, from Java. It is very slow growing at Tocklai but may be found useful on teelas in Cachar and Sylhet, where it has already been introduced. It does not grow well from cuttings.

Lathyrus sativa, known in Bengal as the cluster bean, has been grown this year. It grew very well indeed but was suddenly killed out by a disease of the roots. Experiments with this crop are proceeding.

LEGUMINOUS TREES.

The roads and paths about the station have been planted out with specimens of leguminous and other trees likely to be of value to the tea industry. Some observations on the growth of these may be of value.

THE GENUS ALBIZZIA.

The species *stipulata*, *lebbek*, *oderatissima*, *procera*, and *moluccana* have been planted. Of these *Albizzia moluccana* grows the most quickly. *Albizzia stipulata* was found the most difficult to grow. *Albizzia lebbek* was early attacked be canker but has been cured by the application of Copper soda emulsion.

THE GENUS ACACIA.

Imported species.

As there has been some talk of growing trees for firewood, seed of a number of species of *Acacia* were obtained from Australia.

The common black wattle *Acacia decurrens* was found to grow satisfactorily but the other species which includes *Acacia pycnantha* and *dealbata* have not done so well.

Indigenous species.

Acacia catechu and *Acacia arabica* have been planted and are growing well. It may be mentioned that the former has been planted instead of Sau trees on gardens and appears to be doing good. There are no nodules on the roots of *Acacia* trees.

THE GENUS ERYTHRINA

All the species of this genus grow very vigorously during the first year but they soon become infected by borers. They do not appear to be suitable plants for growth in tea in North East India.

Specimens of many other trees have been planted but as they exhibit no special features they will not be dealt with in detail.

NOTES.

Testing for Acidity of Soil with Litmus Paper.—(Canadian Dept. of Agric., Chemistry Div., Bull. 80).—In this Bulletin two methods of testing for acidity or sourness in soil by means of litmus paper are described :—

"1. Take up, by means of a spade or trowel, a little of the surface soil from, say, half a dozen places on the area to be examined, and mix well, using the trowel or a clean piece of board. Do not handle the soil. Take a small quantity (a few ounces) of the mixed soil and, putting it in a clean cup or tumbler, pour on a little boiled water and stir with a clean piece of stick or spoon until the mass is of the consistency of a very thick paste. Into this "mud" press a piece of blue litmus paper by means of a small stick or the back of the knife, inserting the paper until one-half to two-thirds of its length is within the pasty mass. At the end of fifteen minutes carefully draw out the paper and note if the part that has been in contact with the soil has turned red. If so, the soil is acid.

"2. Place a strip of blue litmus paper in the bottom of a clean, dry, glass tumbler (preferably flat-bottomed), and over it place a round "filter paper" (purchasable at a druggist's) or, if such is not readily obtainable, a piece of clean white blotting paper cut to fit the bottom of the tumbler. On this put a few ounces of the soil to be tested, collected and mixed as already described, and put on sufficient boiled water to moisten or wet the soil thoroughly throughout its mass, but no more, and set aside for half an hour or longer. To examine the litmus paper the tumbler is inverted ; viewed through the bottom of the glass its colour will be well brought out against the white filter paper. As a check, and to ensure that any change in colour may not be due to acidity of the water or filter paper used a blank test should be made in the same manner but using no soil."

NOTE.—Extract from the Journal of the Board of Agriculture, Vol. XXII. No. 20, March, 1916.

Prices of Manures —Since a note on this subject was issued in the Quarterly Journal Pt. IV, 1916, the most noticeable alterations in prices have been the increase in the cost of Dried Blood, which is regretable as this manure has proved suitable for most light soils and has the advantage of containing a high percentage of nitrogen and consequently is suitable for use on estates to which freight charges are high. For all light soils oilcake at present undoubtedly gives the best value for money where nitrogen alone is required, and the comparatively poor results which were obtained from this class of manures a few years ago is not likely to be experienced now because most soils on which this occurred have now received lime which has probably corrected the aggravated acidity which accounted for the poor results obtained.

Nitrate of Potash had advanced slightly but is still one of the most economical manures to use at present in cases where green cropping is being done or where potash is known to be required. It is of use in cases where green cropping is being done because it supplies nitrogen and potash in an available form, the potash largely in excess of the nitrogen, and if a quantity be used sufficient, e.g. 1 to 1½ mds. per acre, to supply enough nitrogen to give a satisfactory start to the green crop, the potash will be of great value in improving the total growth in six weeks of the green crop.

The relative cheapness of bones is still maintained.

A very cheap source of nitrogen is the manure described as Ligox, but we have not yet had an opportunity of making a trial of this manure.

NOTE.—The letters *a*, *b*, *c* and *d* denote different suppliers.

MANURES.	Percentage Composition. N.	Percentage Composition. P_2O_5	Percentage Composition. K_2O	Price per ton.	Unit price. N.	Unit price. P_2O_5	Unit price. K_2O	Remarks.
Nitrogenous Manures—				Rs. As. P.	Rs. As. P.	Rs. As. P.	Rs. As. P.	
Nitrate of soda ...	(*a*) 15/16	...	...	(*a*) 285 0 0	(*a*) 19 0 0	...	...	
	(*b*) 15/16	...	...	(*b*) 285 0 0	(*b*) 19 0 0	...	...	
	(*c*) 15/16	...	...	(*c*) 290 0 0	(*c*) 19 5 4	...	...	
Sulphate of ammonia	(*a*) 20/21	...	...	(*a*) 310 0 0	(*a*) 15 8 0	...	...	
	(*b*) 20/21	...	...	(*b*) 330 0 0	(*b*) 16 8 0	...	...	
	(*c*) 20/21	...	...	(*c*) 310 0 0	(*c*) 15 8 0	...	...	
Nitrate of lime ...	(*b*) 12¼	...	...	(*b*) 260 0 0	(*b*) 20 12 10	...	...	
Calcium cyanamide ...	(*a*) 18	...	...	(*a*) 315 0 0	(*a*) 17 8 0	...	...	
Nitros	(*a*) 14	...	...	(*a*) 220 0 0	(*a*) 15 11 5	...	...	
Nitre-ammonia ...	(*b*) 18	...	...	(*b*) 305 0 0	(*b*) 16 15 1	...	...	
Dried-blood ...	(*a*) 12	...	...	(*a*) 160 0 0	(*a*) 13 5 4	...	...	
	(*b*) 10	...	...	(*b*) 165 0 0	(*b*) 16 8 0	...	...	
Rape cake ...	(*b*) 4/5	...	...	(*b*) 55 0 0	(*b*) 12 3 6	...	...	
Rape cake meal ...	(*a*) 4/5	...	...	(*a*) 47 4 0	(*a*) 10 8 0	...	...	
Castor cake ...	(*b*) 5/6	...	...	(*b*) 80 0 0	(*b*) 14 8 9	...	...	
Castor cake meal ...	(*a*) 5/6	...	...	(*a*) 80 8 0	(*a*) 14 10 2	...	...	
Ground-nut cake ...	(*b*) 7/8	...	...	(*b*) 85 0 0	(*b*) 11 5 4	...	...	

NOTE.—*The letters a, b, c and d denote different suppliers*—(continued.)

MANURES.	Percentage composition.			Price per ton.	Unit price.			Remarks.
	N.	P_2O_5	K_2O		N.	P_2O_5	K_2O	
Nitrogenous Manures— *(continued.)*				Rs. As. P.	Rs. As. P.	Rs. As. P.	Rs As. P.	
Ground nut meal ...	(a) 6/7	...	...	(a) 52 8 0	(a) 8 1 2	...	...	
I. O. P. oilcake meal...	(c) 4½ (c) 5 (c) 5½	... ...	... ...	(c) 49 0 0 (c) 52 8 0 (c) 56 0 0	(c) 10 14 2 (c) 10 8 0 (c) 10 2 11	.. ..	... ...	
Potash Manures—								
Sulphate of potash ...	... ...	... ...	(a) 25 (b) 25	(a) 200 0 0 (b) 220 0 0	... ...	... ...	(a) 8 0 0 (b) 8 12 9	
Nitrate of potash ...	(a) 10 (b) 10	... ...	(a) 30/35 33	(a) 270 0 0 (b) 285 0 0	... ...	... ...	(a) 3 12 0 (b) 4 1 5	Allowing Rs. 15 per unit of nitrogen.
Phosphatic Manures—								
Basic slag ...	... ...	(a) 13/14 (b) 10/12	... ...	(a) 90 0 0 (b) 95 0 0	... ...	(a) 6 10 8 (b) 8 10 2	... ...	
Superphosphate ...	... ...	(a) 20/22 (b) 20/22	... ...	(a) 110 0 0 (b) 105 0 0	... ...	(a) 5 3 9 (b) 5 0 0	... ...	
Ephos basic phosphate	...	(c) 27 (soluble)	...	(c) 120 0 0	...	(c) 4 7 1	...	
Indofos basic phosphate	...	(c) 18 (soluble)	...	(c) 80 0 0	...	(c) 4 7 2	...	
Basic phosphate ...	...	(a) 14/15	...	(a) 100 0 0	...	(a) 6 14 4	...	
Phosphate of lime ...	...	(b) 11/12	...	(b) 100 0 0	...	(b) 8 11 1	...	
Flour phosphate ...	...	(a) 30/35	...	(a) 80 0 0	...	(a) 2 7 4	...	

Note.—*The letters a, b, c and d denote different suppliers*—(continued.)

MANURES.	Percentage composition. N.	Percentage composition. P_2O_5	Percentage composition. K_2O	Price per ton. Rs. As. P.	Unit price. N. Rs. As. P.	Unit price. P_2O_5 Rs. As. P.	Unit price. K_2O Rs. As. P.	Remarks.
Bone Manures—								
Steamed bone meal ...	(a) 3½ (b) 3½	(a) 22/23 22	... ...	(a) 75 0 0 (b) 80 0 0	... ...	(a) 1 13 1 (b) 2 0 9	... ...	Allowing Rs. 10 per unit of nitrogen.
Unsteamed bone meal	(a) 3½ (c) 4	22/23 22/23	... ...	(a) 70 0 0 (c) 67 0 0	... ...	(a) 1 9 6 (c) 1 3 8	... ...	
Bone dust ...	(b) 3 (c) 3	22 18	... ...	(b) 65 0 0 (c) 62 0 0	... ...	(b) 1 9 6 (c) 1 12 5	... ...	
Guanos—								
Raw Peruvian guano...	(b) 12	30	2	(b) 310 0 0	...	(b) 4 1 1	...	Allowing Rs. 15 per unit of nitrogen, and Rs. 4 per unit of potash.
Dissolved Peruvian guano No. (1) ...	(b) 5	25	2	(b) 240 0 0	...	(b) 6 4 6	...	
Dissolved Peruvian guano No. (2) ...	(b) 4	25	2	(b) 210 0 0	...	(b) 5 10 10	...	
Equalised Peruvian guano ...	(b) 8/9	4/5	5/6	(b) 200 0 0	...	(b) 15 0 0	...	

NOTE.—*The letters a, b, c and d denote different suppliers*—(concluded.)

MANURES.	Percentage composition. N.	Percentage composition. P_2O_5	Percentage composition. K_2O	Price per ton.	Unit price. N.	Unit price. P_2O_5	Unit price. K_2O	Remarks.
				Rs. As. P.	Rs. As. P.	Rs. As. P.	Rs. As. P.	
MEAT AND FISH MANURES—								
Sterilized animal meal (ordinary) ...	(a) 7/8 (b) 7/8	7/8 7/8	½ ½	(a) 135 0 0 (b) 135 0 0	(a) 15 13 7 (b) 15 13 7	... ...	... ...	Allowing Rs. 2 per unit of phosphoric acid, and Rs. 3-3-0 per unit of potash.
Sterilized animal meal (special) ...	(a) 7/8 (b) 7/8	7/8 7/8	2½ 2½	(a) 140 0 0 (b) 140 0 0	(a) 15 7 7 (b) 15 7 7	... ...	... ...	
Sterilized animal meal (acme) ...	(a) 8½ (b) 8½	5 5	5 5	(a) 160 0 0 (b) 160 0 0	(a) 15 12 0 (b) 15 12 0	... ...	... ...	
Milled fish ...	(a) 5/7	5/7	...	(a) 130 0 0	(a) 19 10 8	...	...	
Sardine guano ...	(b) 5/7	10/12	...	(b) 140 0 0	(b) 19 10 8	...	...	
Fish guano ...	(a) 7/8	9/10	...	(a) 160 0 0	(a) 18 12 9	...	...	
Milled fish guano ...	(b) 8	10	...	(b) 165 0 0	(b) 18 2 0	...	...	
Nervox	(a) 10	4	...	(a) 125 0 0	(a) 11 11 2	...	...	
Ligox	(c) 10	4	...	(c) 70 0 0	(c) 6 3 2	...	...	

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